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Case report

Locking screw augmentation in hypertrophic nonunion of tibia: a novel surgical technique

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Abstract. *Background and aim:* Nonunion is a common complication in long bone diaphyseal fracture. Hypertrophic nonunion is commonly caused by mechanical instability due to high strain at the fracture site whereas atrophic nonunion is mainly caused by biological impairment. We present our surgical option in hypertrophic nonunion of lower limb. *Methods:* We reported a 45-year-old man clinical case, complaining of pain localized to the left ankle after a high-energy trauma. He reported a distal meta-diaphyseal tibial fracture associated to the fracture of the fibula, surgically treated with open reduction and internal fixation with a medial bridge plate for the tibia, and distal plate for the fibula. After surgery, radiographic monitoring showed a poor progression in the consolidation process. At seven months, CT scan confirmed a Hypertrophic nonunion (HN) of the tibia. We decided to maintain the previous hardware and to gain more stability adding a locking screw in the metadiaphyseal region. *Results:* Radiographic evaluations carried out three months after surgery showed that the fracture line was radiographically filled by bone callus. No pain, no limp, no signs of infection or implant failure were reported. *Conclusions*: Locking screw augmentation could represent a valid technique to reduce micromovements and to increase the stability at the fracture site with the possibility of early weight bearing and good clinical outcome. (www.actabiomedica.it)

Key words: Nonunion, Hypertrophic nonunion, surgical technique, locking screw augmentation

Introduction

Nonunion is a common complication in long bone diaphyseal fracture; it typically occurs in fractured bones that don't heal completely within nine months from injury and that don't show any radiological improvement within 3 months consequently any conservative or surgical intervention (1). The definition of nonunion is well debated: some authors considered six months as the time-frame to classify a painful delayed union as a nonunion (2).

Specific anatomical areas known to have a higher incidence of nonunion than others include the humerus, femur and tibia. Young age, cigarette smoke, high glycate hemoglobin, diabetes mellitus, opioid user, infection, type of fracture and mechanical instability should be considered as risk factors for nonunion (3-7).

In hypertrophic nonunion (HN) treatment, the type of fracture and the previous surgical treatment are determinant during the decision making. In this case, the main cause of healing impairment is the insufficient mechanical stability of the fragments. Therefore, the final treatment aims to increase the stability of the osteosynthesis and the resistance to rotational load and bending forces in order to

improve micromotion and minimize the stress that is necessary for callus formation and bone remodelling (8,9). There is no global consensus about the best choice in the treatment of HN because each technique presents several limitations. Exchanging nail activates periosteal vascular reaction after the reaming procedure because it is well known that it is able to provide a greater stability with a larger diameter implant (10,11). Debridement and plate augmentation with or without additional bone grafting provide good results but they are more difficult to perform and require a higher expertise (12). The Poller screw augmentation technique is indicated for the isthmic HN (13). Exapod external fixation or distraction osteogenesis require the removal of the previous implant and in some case fibular osteotomy too. (14). At last, conservative treatment is often chosen for patient with high intraoperative risks as elderly patients at risk of delirium, dementia, uncontrolled hypertension, acidosis (15). In this complex framework, we describe our surgical procedure called "locking screw augmentation" in case of tibial HN after a primary reduction and osteosynthesis with plate and screws.

Case report

A 45-year-old man presented at our emergency room (ER) complaining of pain localized to the left ankle after a high-energy trauma due to an accidental fall at work. He was a smoker with no relevant comorbidities in his past medical history. He reported a distal meta-diaphyseal tibial fracture associated to the fracture of the fibula. He was surgically treated with open reduction and internal fixation with a medial bridge plate for the tibia and distal plate for the fibula (Figure.1). After surgery, he immediately started active and passive mobilization of the ankle. After thirty days, he progressively started a partial load on the affected limb. We radiographically monitored the progression of the fracture healing with a close follow-up and we noticed a poor progression in the consolidation process. After three months, he started magnetotherapy. At seven months, he had full weight bearing on the affected limb, good healing of the skin with no sign of infection and no pain. The radiographic examination showed abundant callus with a black line at the fracture site after seven months from the surgery procedure (Figure.2). Computer Tomography (CT) scan confirmed a HN of the tibia but did not show signs of loosening of the implant (Figure.3). In our opinion, Magnetic Resonance imaging (MRI) was not necessary, because we did not need to study soft tissue.

Figure 1. A) Patient with distal metadiaphyseal tibial fracture: AP view; B) Patient with distal metadiaphyseal tibial fracture: lateral view.

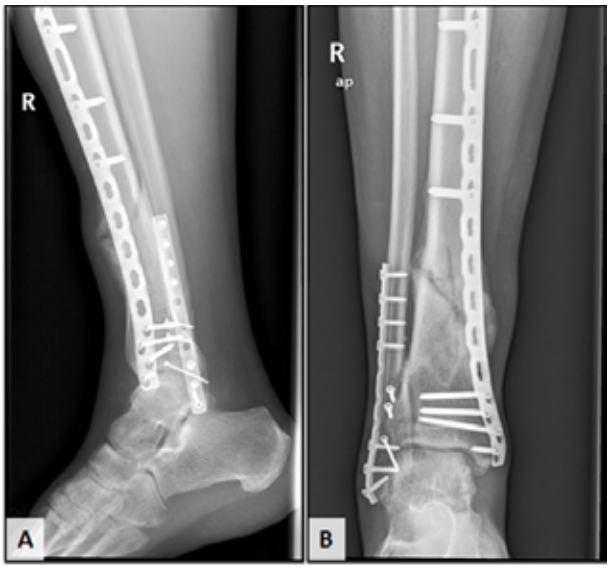

Figure 2. A) Radiographic appearance (lateral view) at six months after surgical treatment that shows HN; B) Radiographic appearance (AP view) at six months after surgical treatment that shows HN.

Figure 3. Preoperative CT scan confirms HN.

Preoperative management

We started to think about a resolutive procedure for this case of HN. The original fracture pattern was retrospectively analyzed in order to consider if the current implant was the best choice or if it should be reconsidered but we excluded planning or technical pitfalls. According to the literature, we fixed the tibia choosing a bridge plate that was triple longer than the site of fracture and we fixed it using screws in at least six cortices on either side of the fracture avoiding to fill every hole (16,17). We also excluded septic nonunion with regular laboratory exams such as c-reactive protein, procalcitonin and erythrocyte sedimentation (14,15).

Before planning our second surgery procedure on the HN, we conducted a survey among a specific orthopedic website Vumedi (https://www.vumedi.com/discussion/distal-tibia-fracture-nonunion/) presenting our case and asking to the scientific community "How would You treat this case?". We received different answers. The most popular provided surgical options were exchange plate with nail, injection of bone marrow aspiration concentrate (BMAC) at the fracture site alone, to keep the same plate and debride fibrous callous with cancellous bone graft or to continue to observe unless pain or hardware failure occurs. This survey underlines that there is no scientific consensus on how to treat HN. In the absence of a unique suggestion, we decide to perform our procedure in which the primary concern is to gain more stability at the fracture site during nonunion.

Surgical technique

Our surgical technique is indicated in case of distal meta-diaphyseal tibial HN previously treated with plate and screws, after six months of follow-up. Case of infection, AN and pathological fractures in our opinion are controindications because these pathologies required a previous debridment. Malunions that required further realignment procedure are also excluded. During the planning with radiographic exams, the primary concern was to gain more stability at the fracture site. The more instable fragment is identified in order to insert the locking screw in the selected hole. The procedure is performed under loco-regional anesthesia. The patient is placed in supine position. A pillow is placed under the buttock to internally rotate the leg. Sterile draping is prepared and fluoroscopy is used. A small longitudinal straight incision of about 1 cm is centered over the selected hole of the plate. Then the plate hole is filled with the locking screw (Figure.4). The skin is then sutured. Three hours after the procedure the patient was discharged.

Postoperative management

Partial weight bearing is allowed for twenty days after the surgical procedure. In this period patient is recommended to move ankle and foot. After the removal of the bandage, rehabilitation is continued. Over the next three weeks, patient gradually returns to his normal activities, the range of motion of the ankle was completed and the weight bearing is complete. At

Figure 4. A-B) Fracture healing after locking screw augmentation.

three months follow up the fracture line is radiographically filled by bone callus. No pain, no limp, no signs of infection or implant failure were reported.

Discussion

The biology of the bone tissue is important in directing the reparative process: a high rate of proliferation, differentiation and activity of the osteoblasts, an adequate supply of blood and growth factors determined by angiogenesis, are all factors that could have favored the resolution of the nonunion, even after the execution of a minimal surgical procedure, such as that described in this work. Many surgical techniques are reported to treat HN. No standard surgical protocols are described, even if the use of exchanging nail is the most applied method (18).

Our surgical treatment is indicated in case of tibial HN previously treated with plate and screws without sign of infection and malalignment. In their study Niikura et al. reported nearly 80% of nonunion after inadequate mechanical stability or reduction (19). We affirmed that locking screw augmentation is not a simple rescue technique but this procedure increases the strain of a well implanted construct. With this surgical technique, we easily impact on several biological and biomechanical aspect of the bone healing. It is known that when compression is not fully achieved across the main fracture, simple fracture patterns can evolve in delayed bone healing and nonunion (20). Our technique increases the stability with the possibility of early weight bearing because we used a locking screw in the more unstable fragment that reduced the excessive strain at the fracture line (8).

During the preoperative planning, although open reduction can promote good fracture osteosynthesis, it should be considered that closed reduction can better protect blood supply and soft tissue. Some authors assessed that nail and mini invasive plate osteosynthesis (M.I.P.O. technique) have lower rate of nonunion versus open reduction and internal fixation osteosynthesis in tibial fracture even if they did not mention the role of the classification of the fractures (7). It is important to preserve soft tissues in order to reduce risk of infection and septic failure. With our technique, we minimize the trauma for the soft tissues. Both our procedure and Poller augmentation technique present low postoperative pain and minimal intraoperative risks (21). The Poller screw augmentation technique has the same rationale of our technique and it can be applied in case of a pre-existing nail (13) whereas our technique in case of previous plating. This is the first report that describes the use of locking screw augmentation to treat HN in long bones. The strength of this technique is that is minimally invasive and it doesn't require the removal of the previous implant. The principal limit is the lack of a great numerosity and the indication requires case of HN previously treated with plate and screws and that construct is well build up.

Conclusions

Our case demonstrates that this technique is simple to perform, it does not require tourniquet, electrosurgical knife or any other particular surgical equipment. The safety of the technique is ensured by the presence of the pre-existing osteosynthesis and it requires few minutes and a small incision. The use of the locking screw augmentation technique seems to have good outcomes with a short time hospitalization and a fast recovery. Further comparative studies are necessary in order to reach a consensus about the best option to treat HN.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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